THE SIGNIFICANCE OF THE PITUITARY IN THE DEVELOPMENT OF ADAPTATION TO HYPOXIA

N. A. Roshchina

ABSTRACT: In this paper we study the role of the pituitary in the process of adaptation of rats to hypoxia. The experiments were carried out on white rats both intact and hypophysectomized. The adaptation of the animal to hypoxia was carried out in the mountains at altitudes of 2000-3800 m. In the animals we investigated the red blood, the weight and the altitude tolerance during "ascent" in a pressure chamber. The investigation showed that in the hypophysectomized animals the altitude tolerance to acute hypoxia is increased on a background of progressive anemia.

Removal of the pituitary does not essentially change the altitude tolerance of the animals who have been operated on in comparison with the intact animals.

In evaluating hypoxic hypoxia as an influence which produces /166
the development of overall functional stress it is natural to assume that the increase in activity of the pituitary has significant value for the adaptation of the organism to oxygen deficiency.

This point of view has a definite experimental basis. Thus it is known that the introduction into the animals of ACTH (adrenal corticotropic hormone) increases their tolerance to acute hypoxia [4,5].

To understand the physiological mechanism of reordering of the organism in the process of adaptation to hypoxia, it is interesting to explain the possibility of the development of adaptation by removing the "pituitary" link.

From the literature several investigations are known in which the tolerance of animals to acute hypoxia has been studied after re-/167
moval of the putiutary. The results of these papers are quite contradictory. Thus, Kou (as Kolpakov and Lauer [2] show) observed a decrease in the tolerance of the hypophysectomized animal to acute hypoxia.

In 1949 Kolpakov and Lauer noted an increase in the altitude tolerance in hypophysectomized animals after showing that following hypophysectomy during a prolonged stay of the animals under conditions of a rarefied atmosphere the adaptive reactions of the blood are lacking: an increase in the amount of hemoglobin and the number

of erythrocytes. On this basis the authors expressed the opinion that the removal of the pituitary facilitates development of adaptation of animals to conditions of prolonged stay in a gaseous environment with as low as possible oxygen pressure [2].

In 1953, Bach and Berry detected a lowered tolerance to acute hypoxia in hypophysectomized animals [7]. In 1962 Markin and Urkov did not note any substantial change in the altitude tolerance of animals in the earlier [7-10 days] periods of time following hypophysectomy [3].

In studying the tolerance of animals to the effect of the radial accelerations which produce the development of circular hypoxia Polis [6] found an increase in the survival of the hypophysectomized animal. This effect with an increase in the time following the operation of the removal of the pituitary became more clearly expressed. Thus, in the literature available to us there are contradictory data relative to the effect of removing the pituitary on the tolerance of animals to acute hypoxia and there are practically no data relative to the possibility of adaptation of hypophysectomized animal to prolonged residence under conditions of oxygen deficiency in the inhaled air.

The purpose of this paper was to study the characteristics of the development of the adaptation syndrome to prolonged effects of hypoxia in animals following removal of the pituitary.

METHOD

The experiments were carried out on white male rats with a weight of 120-180 gm. The pituitary in the animals was removed by operation based on the method developed by Bagramyan and Sakhatskaya [1][1]. Following the operation on the animals for 5-7 days they were placed in a thermostat, a large cage, where a constant temperature of +26° C was maintained. To prevent any unbalance in the aqueous-saline and the carbohydrate metabolism of the animals who were operated on, they were given a solution containing glucose (5%) and NaCl (1%).

Adaptation of the animals to lowered barometric pressure was /168
carried out in mountains where 10 hypophysectomized and 10 intact animals were placed for a period of 10 days at an altitude of 2000 m and for 14 days at an altitude of 3700 m. As a control we used the hypophysectomized and the intact animals of the same age and sex subjected to conditions of normal barometric pressure, i.e., they were not subjected to the effect of "altitude".

[1] The operation and the anatomic control were carried out by Bogachevaya.

To evaluate the adaptation effect in the experimental animals we investigated the blood (the amount of hemoglobin and the number of erythrocytes) and the body weight and determined the tolerance to acute hypoxia in the pressure chamber by means of gradual ascent.

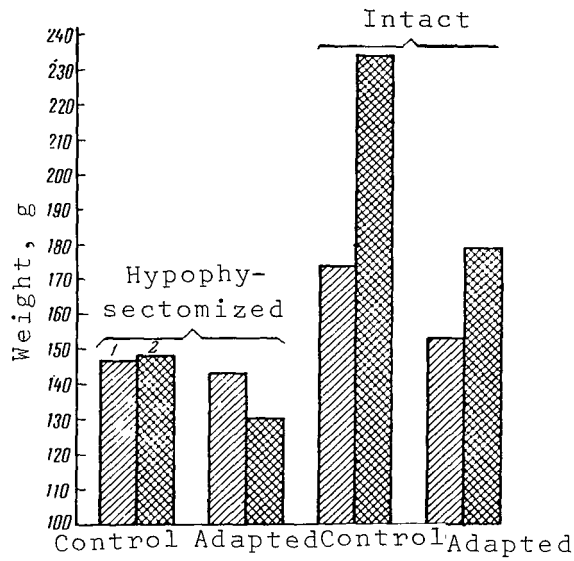

Fig. 1. The Weight of the Hypophysectomized and Intact Animals Before (1) and After (2) the Experiment (Mean Data).

RESULTS

It is known that removal of the pituitary causes a complicated restructuring of the entire endocrine apparatus and changes in the physiological condition of teh animal. Following hypophysectomy there is noted an involution of all of the glands of internal secretion and a slowing down of growth. According to these changes we can judge as to completeness of removal of the pituitary. In the experimental animals, following removal of the pituitary, in all cases there was detected a lag in the weight of the body in comparison with the control animals which on the average was 35% (see Fig. 1). Along with this the growth in the animals ceased and there was noted an involution in the glands of internal secretion. /169
Weighing the endocrine glands of the hypophysectomized animals showed a decrease in the weight of the thyroid gland on an average of 12%, the thymus 50%, the adrenal glands up to 5% and the testes up to 80%.

An anatomical control showed that in all of the animals with the exception of two the pituitary was completely removed. In these two during the post mortem we found insignificant remains of the

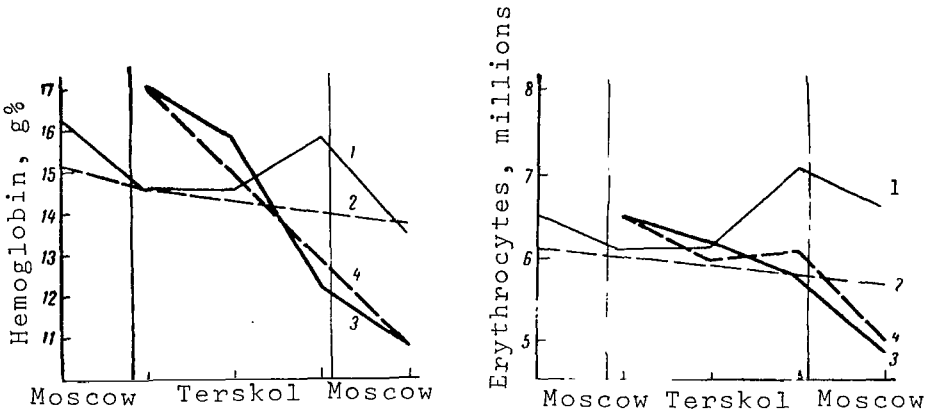

Fig. 2. Change in the amount of Hemoglobin and the Erythrocytes in the Process of the Experiment in Intact and Hypophysectomized Animals. Intact: 1. Adapted; 2. Control; Hypophysectomized: 3. Adapted; 4. Control.

posteriorpart of the pituitary. In the intact residence under high altitude conditions produced a slight lag from the control animals in increase of body weight. The body weight of the hypophysectomized animals under high-altitude conditions was also somewhat less than in the hypophysectomized control animals (Fig. 1).

In the control animals following removal of the pituitary we detected significant changes in the blood system. They appeared in the development of anemia: lowering the amount of hemoglobin and the number of erythrocytes. Analogous changes were detected also in the hypophysectomized animals subjected to conditions of high altitude (Fig. 2). Thus, residence of hypophysectomized rats under conditions of a rarefied atmosphere and altitude of 2000 and 3800 m did not prevent the development of anemia in them.

In a small series of experiments carried out under pressure-chamber conditions with daily ascents to altitudes up to 7000 m, we succeeded in four out of five of the hypophysectomized rats in detecting a slight stimulation of the heopoesis, i.e., an increase in the number of erthrocytes and the amount of hemoglobin. However, this reaction was expressed in the hypophysectomized animals to a lower degree than in the control-intact animals.

Essentially in the hypophysectomized rats, following residence in the mountains, in spite of the development of anemia we detected a distinct increase in tolerance to acute hypoxia (see the table). In the control hypophysectomized animals the altitude tolerance differed practically none from the altitude tolerance of the control intact animal. Here it should be noted only that in one animal subjected to high altitude and in one animal from the control group we detected an exceptionally long lifetime which significantly exceeds the average values. In the statistical interpretation the data obtained in the experiment with these animals were ex-

/170

LIFETIME OF INTACT AND HYPOPHYSECTOMIZED ANIMALS UNDER CONDITIONS OF ACUTE HYPOXIA (11,000 m AND ABOVE)

Group	Experimental Animals										$\bar{x}$	σ	m
	1	2	3	4	5	6	7	8	9	10			
HA	2'12"	5'	6'	3'	6'	4'	3'	6'	11'	43'	6,2	3,3	1,1
HC	5'	2'	1'5"	2'	2'	2'	1'	2'	12'	42'	3,16	1,3	0,43
C	2'	10'	2'	0,5'	2'	2'	2'	2'5"	6'	14'	3,2	2,9	1,0
CA	6'	8'	8'	3'	11'	2'	—	—	—	—	6,3	3,4	1,5

HA = Hypophysectomized, Adapted;
HC = Hypophysectomized, Control;
C = Control;
CA = Control, Adapted.

cluded. It is significant that Kolpakov and Lauer [2] in individual cases also noted in the hypophysectomized animals an extremely long lifetime at high altitude. Possibly the inclusion of data obtained on these animals also led these authors to the conclusion that removal of the pituitary increases tolerance to acute oxygen deficiency.

On the basis of analyzing the data obtained in the experiments we can make the following conclusions:

1. For 38-40 days following removal of the pituitary the tolerance of the animal to acute hypoxia does not change substantially.

2. Hypophysectomy leads to the gradual development of anemia. Residence of hypophysectomized animals at altitudes of 2000 and 3700 m in the mountains does not prevent the occurrence of anemia.

3. In hypophysectomized animals following residence under high-altitude conditions, in spite of the development of anemia, a distinct increase is noted in tolerance to acute hypoxia.

REFERENCES

1. Bagramyan, E.R. and T.S. Sakhatskaya: Problemy endokrinologii i gormonoterapii. (Problems of Endocrinology and Hormone Therapy), No. 5, p. 46, 1962.
2. Kolpakov, Ye.V. and N.V. Lauer: In the book: Gipoksiya. (Hypoxia). Kiev, p. 122, 1949.
3. Malkin, V.B. and Yu. A. Yurkov: Problemy kosmicheskoy biologii. No. 2, p. 393, 1962.
4. Li Choh Hao and U.V. Herring: Amer. J. Physiol., Vol. 143, p.584 1945.
5. Megill, A. and I.I. Marberger: Aviat. Med., Vol. 26, No. 24,

p. 308, 1955.
6. Polis, B.J.: Appl. Physiol., Vol. 16, No. 2, p. 211, 1961.
7. Vacca, C. and Boeri: Rev. Med. Aero, Vol. 16, p. 139, 1953.